PROJECT REPORT ON

DEVELOPMENT OF CERAMIC TILES USING WASTE MATERIALS

A Report Submitted In partial fulfilment of the requirements of B.Tech

(CERAMIC ENGINEERING)

Submitted By

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CERTIFICATE

This is to certify that the project report entitled **"DEVELOPMENT OF CERAMIC TILES USING WASTE MATERIALS"** submitted by **Shambhu bhusan Rana** in partial fulfilment of the requirements for the award of B.Tech Degree in Chemical Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in the report has not been submitted to any other University/Institute for the award of any Degree.

Date:

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Shambhu bhusan Rana

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ABSTRACT

Red mud from aluminium industry and Fly ash from the thermal power plant were regarded as hazardous industry waste all over the world. The present study emphasizes the development of ceramic tiles utilizing red mud and fly ash as raw materials. The bulk density, apparent porosity, wt. loss on sintering, linear shrinkage, water suction, water absorption properties of the developed products are studied carefully. The study showed that tailoring the composition ceramic tiles could be made utilizing up to 50% red mud when used along with clay and up to 80% west utilization when used in combination (red mud and fly ash together) with clay.

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CHAPTER 1

INTRODUCTION

The huge volumes of industrial waste generated today represent one of the world's greatest ecological issues and recycling has emerged as a very important environmental issue nowadays due to the reducing nature resources and the increasing amount of solid wastes. Red mud, as one of the major solid wastes, is generated in the process of alumina extraction from bauxite. Due to its caustic nature, it poses a major ecological issue. Fly ash is another waste residue generated as a byproduct Of coal combustion in power stations. This industrial waste is regarded as hazardous material all over the world, which presents serious problems related to land disposal and environmental pollution.

CHAPTER 2

LITEREATURE REVIEW

Red Mud:-

The huge volumes of modern waste produced today speak to one of the world's most terrific natural issues and reusing has developed as an exceptionally vital ecological issue these days because of the reducing nature assets and the expanding measure of solid wastes. Red mud, as one of the real solid wastes, is created currently alumina extraction from bauxite. Because of its harsh nature, it represents a real environmental issue. For each ton of alumina produced, roughly 1–1.5 tons of red mud is created the whole time. In India at present just a little rate of this waste is used, fundamentally in the cementitious items (cement and bond), the rest of specifically released into lakes or landfills, which is viewed as unattractive, earth undesirable and a non-gainful utilization of area assets, and in addition representing an on-going money related trouble through their long haul-upkeep. Red mud is the insoluble by-item created throughout the processing of aluminum, from the response of mineral bauxite and the sodium hydroxide at high temperature and weight throughout the Bayer process. Red mud is exceptionally soluble, with a ph extending from 10 to 13. Yearly overall preparation has been assessed at 70 million ton, in spite of the fact a few authors propose different amounts, e.g. more or less 90 million tons. In Galicia (Spain), the measure of red mud as of now being stored is 15 million tons, and that figure is expanding by 1 million tons for every year. Legitimate transfer of red mud costs organizations around 5% of the handling worth of the aluminum. This waste is made basically out of salts, iron oxides and hydroxides, aluminum hydroxides, calcium carbonate, titanium, and silica. Lately, much research has been performed to support the reuse of red mud. This waste is constantly utilized, for instance, as filler in PVC, in the production of reactant materials, and in colors. Studies have additionally prompted the recuperation of some significant components and the adjustment of clayey liners. Furthermore, red mud has been utilized as a part of the assembling of ways, recuperation of uncommon earth components, and the preparation of concrete. In spite of these developments, the huge measure of red mud 1–1.5 tons for each ton of aluminum, since the routines for reuse created so far don't devour red mud in expansive amounts. Therefore alternative use of red mud will process noteworthy profits regarding environment and matters in profit making by reducing landfill volume, sullying of soil and ground water, and release of land for alternative uses

Fly Ash:-

Fly ash is an another waste buildup produced as a result Of coal ignition in power stations . This modern waste is viewed as risky material everywhere throughout the world, which displays genuine issues identified with area transfer and ecological contamination. Then again, in India , there are more thermal power plants being manufactured to day to fulfill the expanding interest for vitality assets. What's more a huge number of huge amounts of coal fly ash are created every year. Along these lines, the improvement of new requisitions for fly ash is Necessary keeping in mind the end goal to reduce dependence on landfill and couldbe Helpful in diminishing natural contamination, as well as in producing high value added products.

Potential of Fly Ash:-

- A alumino -silicate material
- Fine PSD with good flow ability
- Combination of crystalline and glassy phases
- Pozzolanic characteristic
- Good durability
- Refractory properties

Fig 2.1 fly ash resorvior

Fig 2.2 Red mud resorvior

PREVIOUS STUDIES ON USE OF RED MUD AND FLY ASH

- **Anuj Kumar & Sanjay Kumar (2012)** Developed paving block from red mud & fly ash using geopolymerization. He prepared paving block of scientific standard using 10-20% of red mud.
- **Sandeep Parma (2013)** Prepared Ceramic Microfiltration Membrane using Red Mud. He prepared a cheaper microfiltration membrane then the similar products.
- **Kacker and Chandra (1977)** prepared Cements from lime, red mud &bauxite or lime, red mud & bauxite & gypsum exhibit strengths comparable or superior to ordinary Portland cement. The most promising proportions seem to be 30–35% of the HINDALCO red mud+15–20% bauxite+7.5–10% gypsum+45– 50% lime depending on the type of cement desired.
- **Amritphale et al (2001)** prepared tiles using red mud and fly ash.
- **Xingjun Chen & AnxianLun (2012**) prepared foam ceramic using red mud and fly ash and sodium silicate as foaming agent and sodium borate as fluxing agent.
- **Jiakuan Yang, Dudu Zhang & Jian Hou (2006)** Prepared glass ceramic using red mud and fly ash. TiO_2 was added as nucleation agent and to improve the ability of glass forming Na_2CO_3 was added .

2.3 Objective of project

- **Development of ceramic tiles from**

  Waste material like Fly ash & Red mud

- **Optimization of compositions to suit application**

- **Characterization of ceramic tiles thus developed.**

CHAPTER 3

MATERIALS AND METHOD

3.1 Raw Material & Sample Preparation

Red mud is supplied by SAIL Rourkela. Red mud sample is first grounded then chemical analysis of the red mud is done for its composition. Composition of red mud is shown in Table 1. It is Fe_2O_3 rich slag containing CaO,SiO_2 & MgO. Fly ash is collected from thermal power plant. It is rich in SiO_2.Ball clay & china clay used as other main raw material. 5% of water is used as binder to increase bonding and plasticity of material. Raw materials are batched as per the proportion required to prepare the sample. The composition of sample is listed in Table 2. The raw material are dry mixed as per proportion listed in Table 2 with addition of 5% of water. Pressing is done after mixing at 5ton pressure with 30sec. pressing time in hydraulic pressure in 60*30 mm rectangular dia. After that drying is processed at 110 ^{0}C for 24 hours to remove water content and to pre-heat the sample to prohibit crack formation in sample. Sintering is done at 1000 ^{0}c for 2hrs.

Table 3.1:- Quantitative analysis of raw materials

	SiO_2	Fe_2O_3	CaO	MgO	Mixed oxide
Red mud	13.61	48.50	4.92	4.72	72.88
Fly ash	60.32	12.68	3.2	3.46	33.42
Ball clay	44.62	2.9	5.9	3.15	40.38
China clay	44.42	4.39	6.9	3.65	39.11

Table 3.2:-Composition of samples

material	R10	R20	R30	R40	R50	R60	R70	R80	R90
Red mud	10	20	30	40	50	60	70	80	90
Ball clay	45	40	35	30	25	20	15	10	5
China clay	45	40	35	30	25	20	15	10	5

material	R40/F30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
Red mud	40	40	40	50	50	50	60	60
FLY ASH	30	40	50	25	30	40	20	30
BALL clay	30	20	10	25	20	10	20	10

2.2 Weight loss after sintering

It's weight change after sintering in other words difference in weight after sintering. Weight of sample is measured before firing called dry weight (D) and after firing (F).

It's calculated as $\frac{D-F}{D} \times 100$

2.3Linear shrinkage

Linear shrinkage is the difference of the size between green body and body after sintering. Size of the sample is measured before sintering (l1) and after sintering (l2) and calculated the percentage change in size.

Linear shrinkage=$\frac{l1-l2}{l1} \times 100$

2.4 Water suction

This test determine the capacity of body to absorb water through capillary action or the succeptibility of water. It's measured by UNE 67-031 standard. First sample is soaked in water for some time then dried at 110 ^{0}c for some time then its weight is measured (w). The surface area of the side we are going to put in water is measured (A).Then the sample is put in 3mm height water for 1min then taken out and extra wter is removed by a cloth and weight is measured (Q).The water suction is measured as

Water suction=$(Q - W)/A$

2.5 Water absorption, Bulk density & apparent porosity

Bulk density is the mass to volume of the sample including holes and surface pore in it. Its measured after sintering of the body.

Apparent porosity is the measure of the open pore of the sample.

These three characteristics are measured by following method. First all sample are boiled for 1.5hrs in heater so that water can enter in to pores of the sample. Then the suspended weight (S) and Soaked weight (W) is measured. The dry weight (D) is measured before the boiling. The characteristic are calculated as follow:-

Bulk Density= $\frac{D}{W-S}$

Apparent Porosity= $\frac{W-D}{W-S} \times 100$

Water Absorption= $\frac{W-D}{D}$

CHAPTER 4:- RESULTS AND DISCUSSION

4.1 Weight loss on Firing

It's weight change after sintering in other words difference in weight after sintering. Weight of sample is measured before firing called dry weight and after firing. Table 4.1 show wt. loss of samples on firing and figure 4.1 show wt. loss on firing of red mud tiles w.r.t red mud%. Weight loss on sintering value linearly decrease from 16.09% to 13.42 % loss of sample with 60 % red mud then increase up to 14.0684%. Red mud- fly ash samples have very low weight loss on sintering as compared to red clay sample. Their value varies in the range 7.56% to 8.91%.

Table 4.1:wt. loss on firing

	R10	R20	R30	R40	R50	R60	R70	R80	R90
Wt. loss on sintering	16.09	14.80	14.26	12.98	13.52	13.42	13.06	13.45	14.06

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
Wt. loss on sintering	8.91	7.56	7.46	14.56	8.83	7.40	7.93	8.81

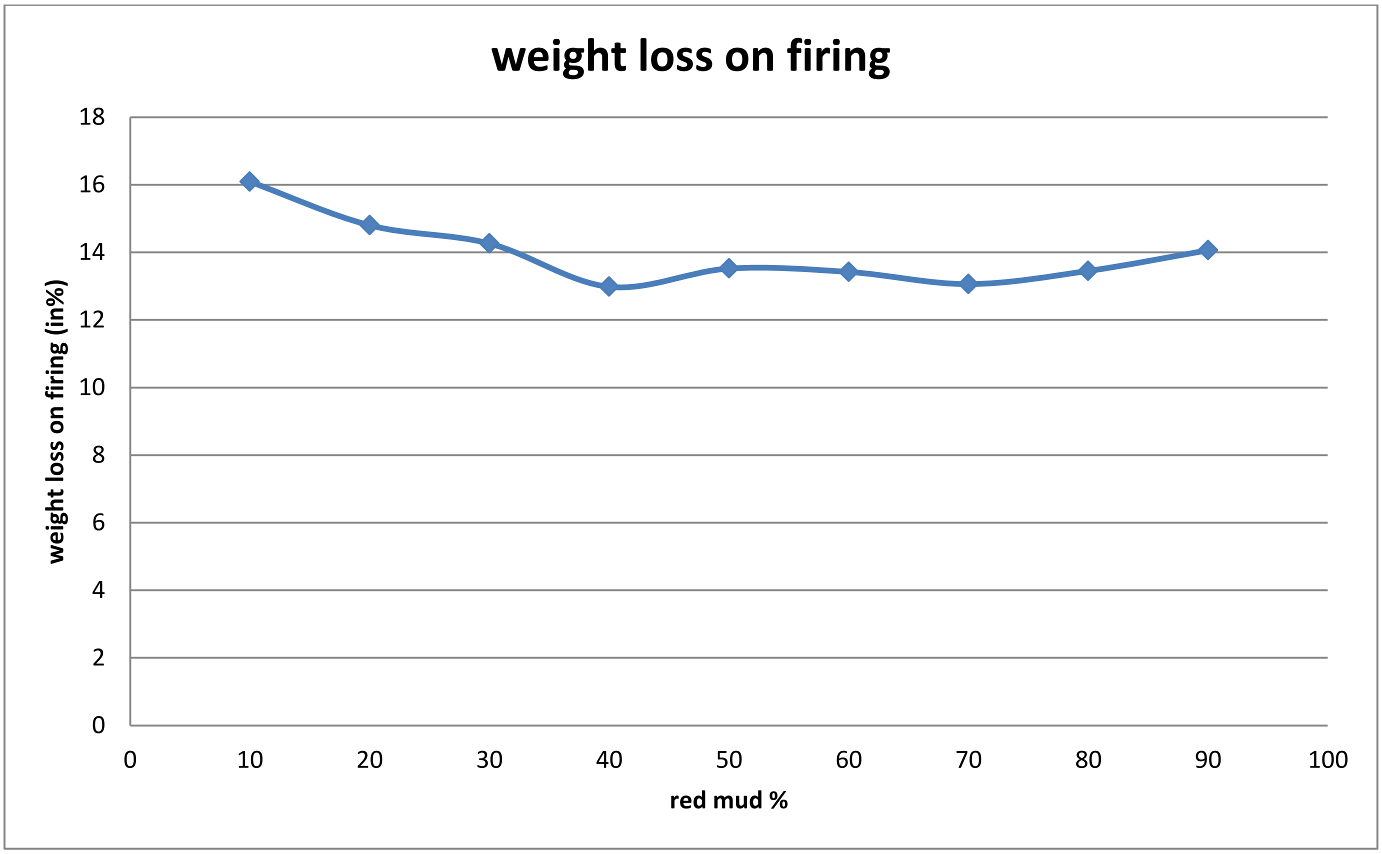


Fig 4.1: weight loss on firing w.r.t red mud%

4.2 Linear Shrinkage

The linear shrinkage that the examples experience throughout the sintering stage is an innovative parameter that must be examined carefully. This stage is one of the most important in the process of manufacturing ceramic materials, since not performing it effectively can prompt stress, cracks, and breaks in the specimens. Table 4.2 shows linear shrinkage of samples and figure 4.2 show linear shrinkage of red mud tiles w.r.t red mud%. Beginning from a red clay substance of 10%, there is an almost linear increase in the shrinkage of the specimens up to 60% then linear reduction in it. Linear shrinkage of red mud-fly ash specimen demonstrate nearly equivalent or more shrinkage then red mud test hence more densification in this manner more stupendous quality. Linear shrinkage is identified with courses of action of pore arrangement and densification of the specimens, and it influences the compressive quality of the samples.

Table 4.2 linear shrinkage of samples

	R10	R20	R30	R40	R50	R60	R70	R80	R90
Linear Shrinkage	0.2539	0.12539	0.22380	0.5809	0.78571	0.7914	0.58730	0.3629	0.0793

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
Linear shrinkage	1.4126	0.2539	0.5914	2.730	0.158	0.131	0.791	0.9365

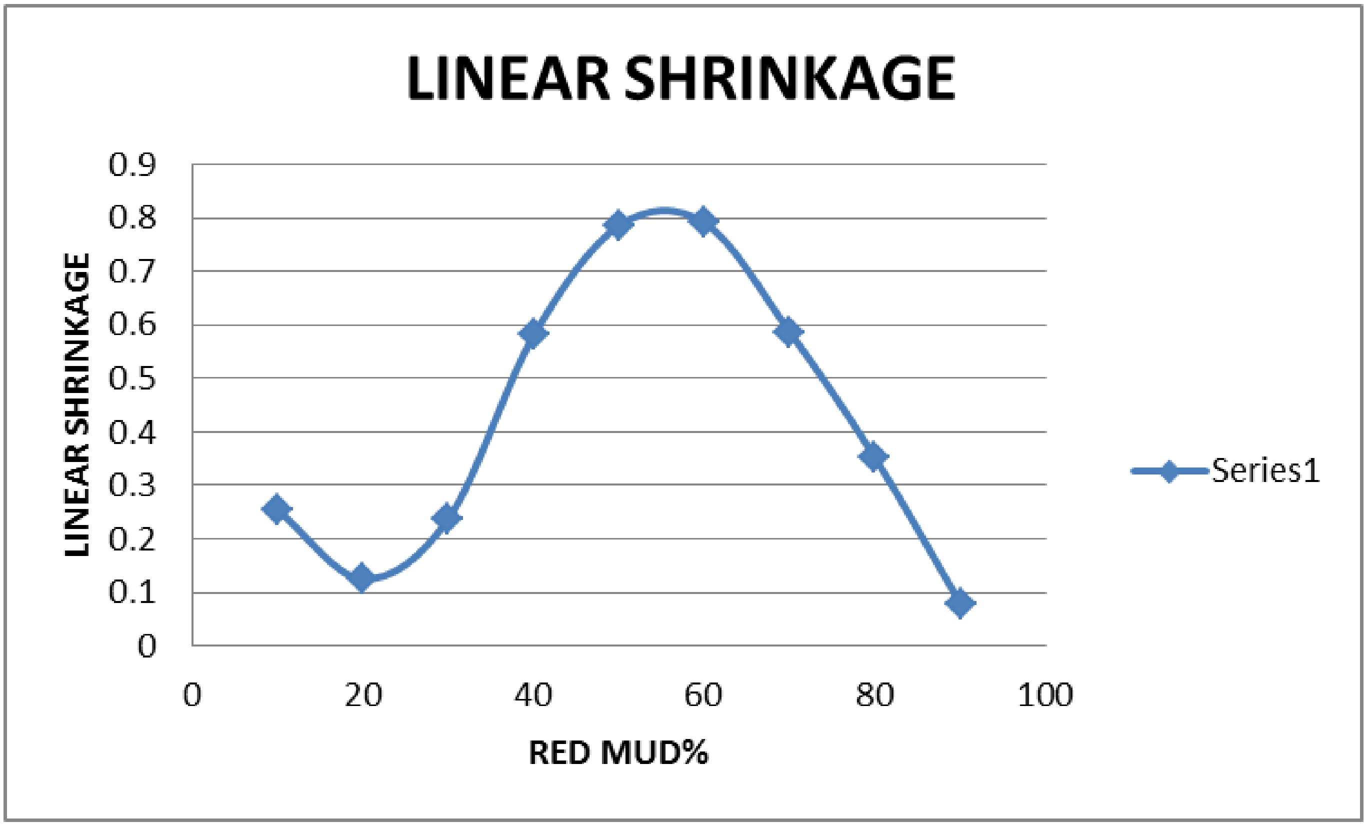


Fig4.2: linear shrinkage w.r.t red mud percentage

Red mud addition decrease porosity and increase density of material thus increase in shrinkage.

4.3 Water suction

The outcomes for the water suction test are exhibited in Table .The water suction of the specimen's decreases as the amount of red mud increases. Table 4.3 show water suction of samples and figure 4.3 show water suction of red mud tiles w.r.t red mud% Water suction achieves at least 0.224895 in specimens with half red mud and expansions to a quality of 0.311564 for examples made with 90% red mud. These effects are demonstrated by a diminishing in the interconnected surface porosity. At 80% red mud in the specimens, the surface porosity stops to be interconnected because of the densification of the examples with a high substance of red mud. These specimens then start to structure macrospores, expanding the water suction to a greatest in the examples of pure red mud. The water suction value of red mud- fly ash sample vary from 0.227354 to 0.310372 where R40/F30 being lowest and R69/F30 sample being highest.

Table 4.3 Water suction of samples

	R10	R20	R30	R40	R50	R60	R70	R80	R90
Water suction	0.36013	0.227737	0.324924	0.241642	0.2248	0.236655	0.2466	0.292364	0.311564

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
Water suction	0.227354	0.243670	0.279171	0.336013	0.265118	0.300306	0.306339	0.310372

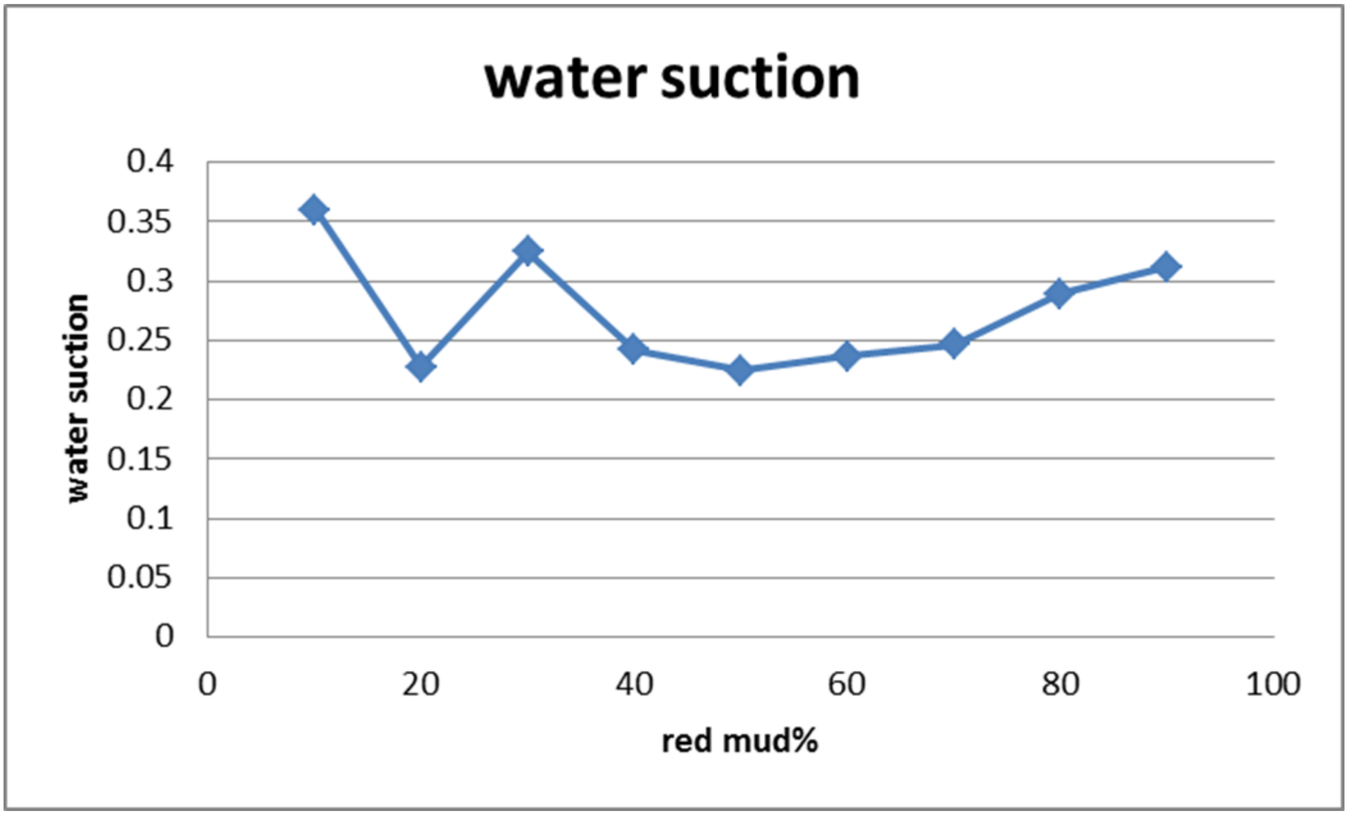


Fig 4.3: water suction w.r.t red mud %

4.4 water absorption

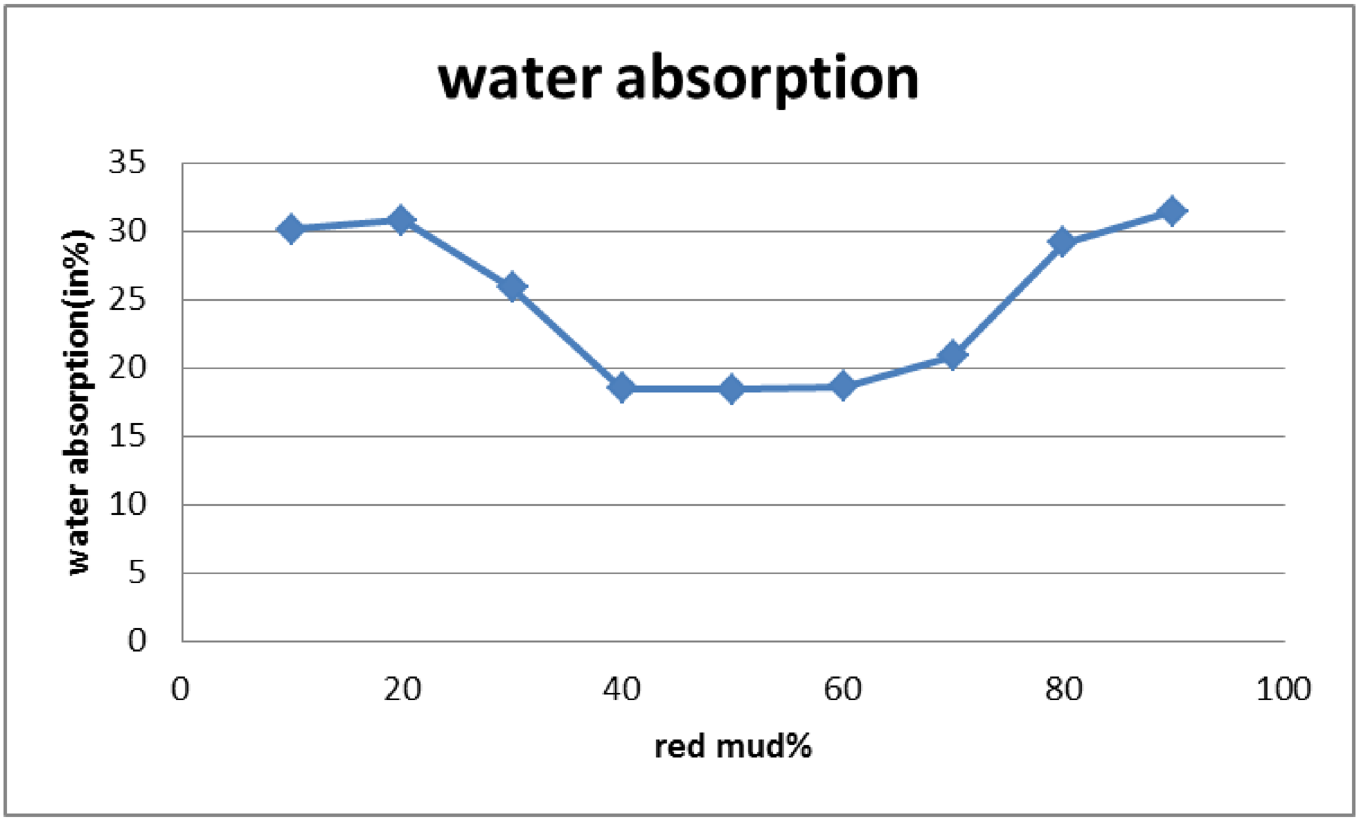
The water absorption test measures the open porosity made in the material. It demonstrates that open porosity diminishes as red mud is added to the examples, because that the material is densified. Table 4.4 show water absorption and figure 4.1 show water absorption red mud tiles w.r.t red mud%. We see that the water absorption diminishes from a greatest value of 30.1910% for the reference tubes (those manufactured just from clay) to at least 18.05% in the samples manufactured with 60% red mud then increase up to 31.4939. The increase of red mud prompts the shaping of macrospores. These pores close continuously as the amount of red mud increments. The samples' retention capability subsequently decreases to the least value in the specimens that just contain red mud. The total porosity of the sintered specimens could be open or closed. The porosity of the open-pore specimens might be figured by utilizing the water absorptions test. A low value on this test is desirable; as it shows that the examples can better oppose ecological operators and have more amazing durability

.**Table 4.4: water absorption of samples**

	R10	R20	R30	R40	R50	R60	R70	R80	R90
WATER ABSORPTION	30.1910	30.8723	25.9182	18.5579	18.4469	18.6857	20.9011	29.1975	31.4939

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
Water absorption	21.7870	23.1844	27.1968	29.5017	24.7927	27.0180	26.2713	

Fig 4.4 water absorption w.r.t red mud %



Water absorption and linear shrinkage are nearly related, since the more amazing the shrinkage, the more the volume of the empty spaces, and subsequently the bring down the absorption. The more the amount of red mud included, the more vitreous stage is created, which will fill in the pores of the samples and decrease the porosity, in this manner likewise diminishing the amount of water absorbed.

4.5 Bulk Density

The bulk density is the mass per unit volume of a dry brick, including the empty spaces or pores in the brick. bulk density is a property directly related with linear shrinkage. Since the size of the samples diminishes, the weight loss after firing stays steady in the specimens containing red mud, and the volume of the sample diminishes (in spite of the fact that weight remaining about steady), the density of the specimens must increase. Bulk density is also related with compressive strength, since, as the specimens get to be denser, their lower porosity provides for them more terrific compressive strength. Fig4.5 shows the development of the bulk density that corresponding to the amount of red mud added to the mixture. bulk density of the specimen differ from 1.5058 to 2.0637 . Test with red mud 10% show low b.d. whereas specimen with 60 % red mud demonstrate high density.

Table 4.5 bluk desity of samples

	R10	R20	R30	R40	R50	R60	R70	R80	R90
B.D	1.5058	1.5238	1.6836	1.9500	2.0185	2.0637	2.0042	1.8456	1.6871

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
B.D.	1.7650	1.6889	1.5436	1.6607	1.6870	1.5971	1.6576	1.6982

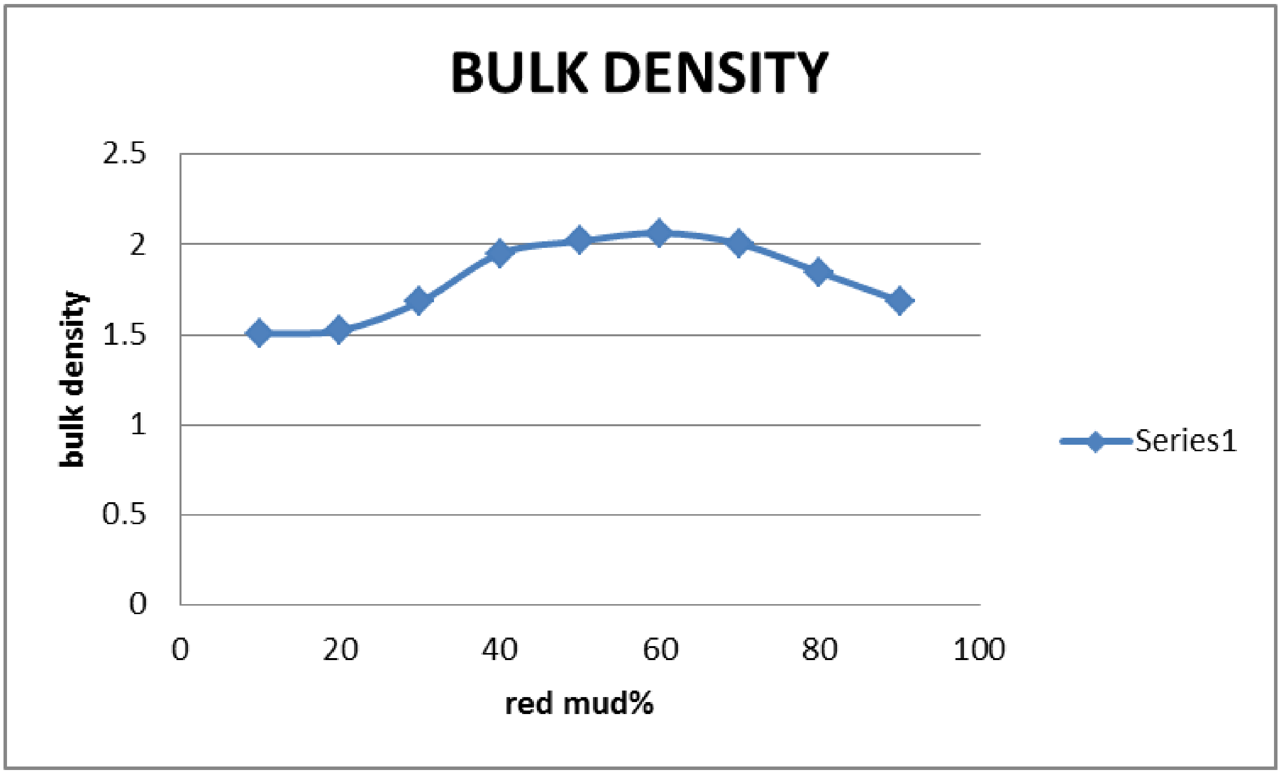


Fig 4.5:Bulk density w.r.t red mud %

Bulk density of red mud- fly ash sample show similar density ranging from 1.5436 to 1.7650.Bulk density is related to compressive strength this result show that samples have good strength thus can be used as construction material.

4.6 Apparent porosity

The total porosity of the fired samples could be open or closed. The porosity of the open-pore samples could be calculated by utilizing the water absorption test. Apparent porosity is open or surface porosity of sample. A low value on this test is attractive, as it demonstrates that the specimens can better oppose ecological agents and have more terrific durability. Apparent porosity related with density and linear shrinkage. Low porosity implies high density and shrinkage. Table 4.6 show apparent porosity and figure 4.6 show apparent porosity of red mud tiles w.r.t red mud%.

Table 4.6 Apparent porosity of samples

	R10	R20	R30	R40	R50	R60	R70	R80	R90
Apparent porosity	45.46	47.42	43.63	36.18	37.31	38.15	41.88	48.45	53.16

	R40/f30	R40/F40	R40/F50	R50/F25	R50/F30	R50/F40	R60/F20	R60/F30
APPARENT POROSITY	38.45	39.15	41.98	48.99	41.82	43.15	43.21	43.34

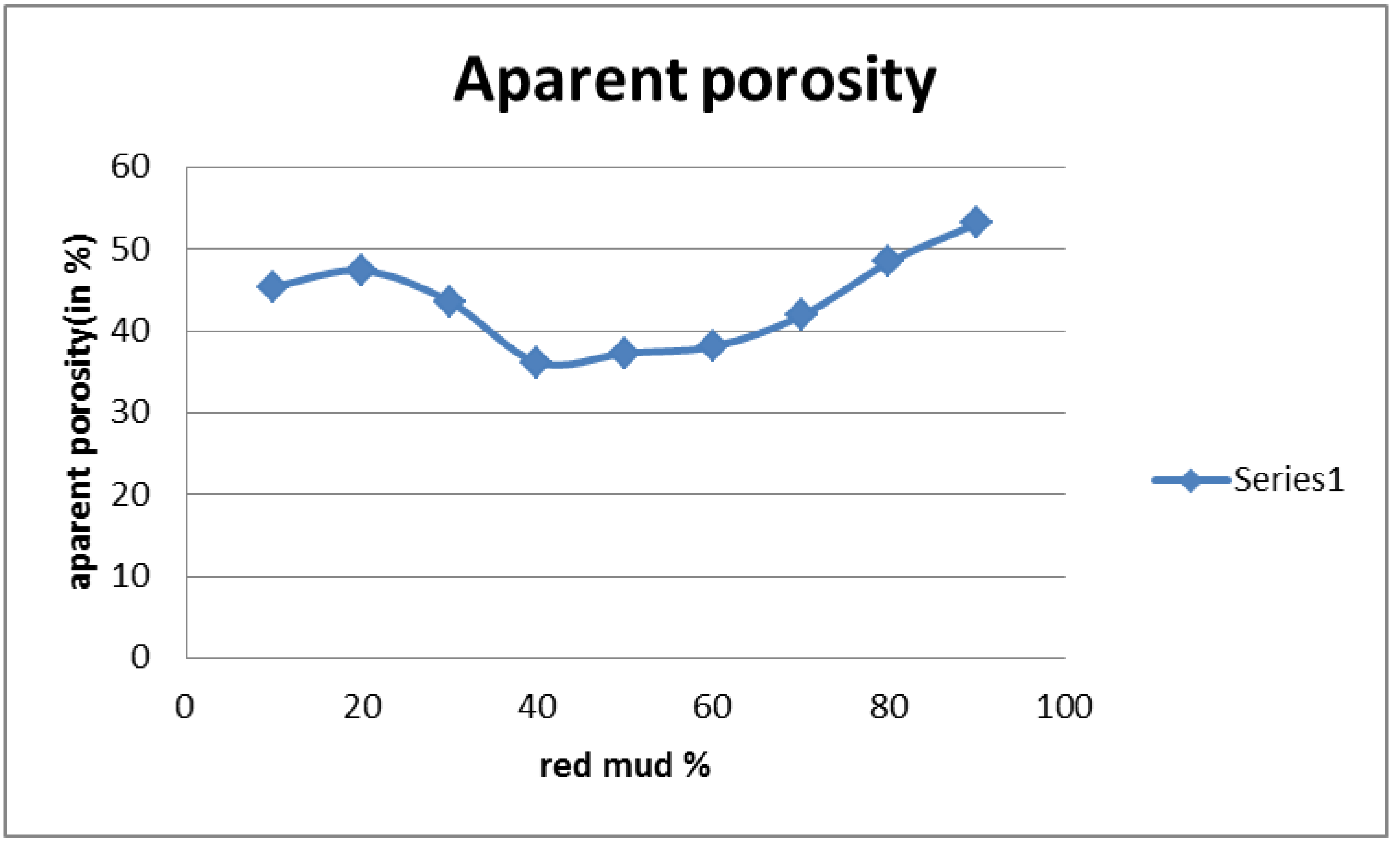


Fig 4.6: Apparent porosity w.r.t. red mud percentage

CHAPTER 5

CONCLUSION

The optimal percentage of red mud to clay in manufacturing ceramic tiles is 50%, and the resulting bricks have a b.d. greater than that of pure clay. The optimal firing temperature was 1000 ^{0}C for 2 h. With 50% red mud, we obtained the following characteristics: linear shrinkage 0.46%, water absorption 18.4469 , weight loss after sintering 2.8947%. Thus, the greater the percentage of red mud added to the ceramic matrix, the greater the quantity of vitreous phase generated. This addition causes the bulk density to increase for the same reason, since the liquid phase fills in the pores, decreasing absorption thus increasing strength.

As we can see composition of fly ash and red mud are giving good properties then red mud & clay tiles .We can effectively use mixture of red mud and fly ash up to 90%. Bulk density found in the range of 1.6 to 1.76 thus good strength. Thus here we concluded that ceramic tiles that are produced can be used in construction work and we found a new angle to use waste material.

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